E-3 PIPE OUTLET PROTECTION

PURPOSE & APPLICATIONS

Pipe outlet protection is a protective armor for the immediate area around the outlet of a pipe or culvert to protect it and the receiving channel from scour and deterioration. This practice is applicable to the outlets of underground conduits designed to dispose of excess surface and subsurface water, culverts, and to principal spillways in detention and sediment ponds. Types of outlet protection are natural plunge pools, ripraped aprons, and ripraped plunge pools. The type of protection should be dependent upon site conditions such as water volume discharge, foundation soils and tailwater.

CONSIDERATIONS

All outlets to hydraulic conduits must be adequately protected from scour caused by the exit velocity, turbulence, and suction of the water leaving the outlet.

The outlets of pipes and structurally lined channels are points of critical erosion potential. Stormwater transported through man-made conveyance systems at design capacity generally reaches a velocity exceeding the capacity of the receiving channel. To prevent scour at stormwater outlets, a flow transition structure is needed which will absorb the initial impact of the flow and to reduce the flow.

Apron: The most commonly used device for outlet protection is a structurally lined apron. This structure protects and stabilizes the fill slope around and above the culvert. The apron is generally lined with riprap, grouted riprap or concrete. They are constructed at a zero grade for a distance that is related to the outlet flow rate and the tailwater level.

Plunge Pool: Where flow is excessive for the economical use of an apron, excavated stilling basins or plunge pools may be used. The plunge pool allows the dissipation of energy at the outlet of the pipe and into the channel.

If the pipe is a stream crossing, fish passage will be an issue and a NRPA permit will be required. The plunge pool design, access and elevation of the pipe will need to be adequate for a constant flow. The Department of Inland Fisheries and Wildlife will need to be consulted for guidance and to determine the design needed for fish passage.

If the drainage pipe discharges into a natural vegetated filter area, an energy dissipator is also required. See LEVEL SPREADER BMP. If the outlet drains into another conveyance structure such as a ditch or constructed swale, only a plunge pool will be needed.

SPECIFICATIONS

Design Criteria

Details must include all dimensions of the structure, D50 of riprap chosen, depth of riprap layer and depth of gravel filter layer.

Fish Passage: The selection of an appropriate outlet protection method must consider the impact on fish passage. In general, the flow depth and velocity must be taken into account. The flow velocity for fish passage generally should not exceed 2 feet per second.

Design: In watersheds less than 640 acres (1 square mile) it is recommended that structures be designed to accommodate flows from the 25 year storm event or check with local and state requirements. Above that acreage, FEMA rules govern and the culvert should be designed for a 100-year storm if it is in a floodplain. DOT requires their structures to pass the 10-year storm.

Natural Outlet Conditions: There are situations where a natural earth pool will be adequate. Where no outlet protection is proposed, it must be shown that THE existing receiving channel conditions (soil type) can withstand the anticipated maximum velocity based on bare soil velocity as found in Appendix B, HYDROGEOLOGIC SOIL GROUPS. The soils on-site must be verified at the time of installation to ensure that they can withstand the design velocities.

Aprons

Structurally lined aprons at the outlets of pipes and paved channel sections shall be designed according to the following criteria:

Tailwater Depth: The depth of tailwater immediately below the pipe outlet during the 10-year storm must be determined for the design capacity of the pipe. Manning's Equation may be used to determine that tailwater depth. If the tailwater depth is less than half the diameter of the outlet pipe, it shall be classified as a minimum tailwater condition and the table at the end of this section may be used. If the tailwater depth is greater than half the diameter of the outlet pipe, then another engineering method needs to be utilized. Pipes which outlet onto an area with no defined channel may be assumed to have a minimum tailwater condition.

Apron Length: The apron length shall be determined from the enclosed table.

Apron width: If the pipe discharges directly into a well-defined channel, the apron shall extend across the channel bottom and one foot above the maximum tailwater depth or to the top of the bank, whichever is less.

If the pipe discharges onto a flat area with no defined channel, the width of the apron shall be determined as follows:

- The upstream end of the apron, adjacent to the pipe, shall have a width three times the outlet pipe's diameter.
- For a minimum tailwater condition, the downstream end of the apron shall have a width equal to the pipe diameter plus the length of the apron.

Note: *Consult with IF&W for sizing criteria if the apron is so wide that the depth of water from the base flow of the stream is too shallow to allow fish passage.*

Bottom Grade: The apron shall be constructed with no slope along its length (0.0% grade). The invert elevation of the downstream end of the apron shall be equal to the elevation of the invert of the receiving channel. There shall be no overfall at the end of the apron.

Side Slopes: If the pipe discharges into a well-defined channel, the side slopes of the channel shall not be steeper than 2H: 1V.

Alignment: The apron shall be located so that there are no bends in the horizontal alignment.

Materials: The apron may be lined with vegetation, riprap, grouted riprap, or concrete. The median sized stone for riprap shall be determined from the included table. If concrete is used in a stream, it must be air dried for 21 days and rinsed prior to contact with water.

Aprons made up of riprap shall be designed and installed in accordance with the RIPRAP BMP. Aprons made up of gabions shall be designed and installed in accordance with the GABION BMP. Both will have piping protection provided by either a gravel filter or appropriate geotextile. When gabion mats are used, the rock filling the baskets shall contain no rock smaller than the mesh of the baskets.

Plunge Pools

Refer to the detail drawings at the back of this section for the proper design of a plunge pool.

"Hanging" culverts: "Hanging" culverts (culverts with a significant drop from the outlet to the stream) with plunge pools will not be allowed on streams with fish migration.

Culvert sizes of 36 inch diameter or less: An outlet pool lined with 6 to 12 inch stone constructed one diameter deep, two diameters wide and four diameters long will provide adequate outlet protection. For example, a 12-inch diameter culvert would require a stone-lined outlet pool 12 inches deep, 24 inches wide and 48 inches long.

Culverts greater than 36 inches: A professional engineer should design these. The installation of riprap shall conform to the RIPRAP BMP. Rock riprap on the sides of the pool shall taper from the top of the pipe at the outlet down to the level of the design high water elevation of the receiving channel for the design storm. A gravel filter or appropriate geotextile shall be used to protect against piping of soil fines from beneath the rock.

MAINTENANCE

Periodically check all aprons, plunge pools and structural outlets for damage and repair them as needed. If any evidence of erosion or scouring is apparent, modify the design as needed to provide long term protection (keeping in mind fish passage requirements if applicable).

OUTLET PROTECTION

FOR A PIPE FLOWING FULL WITH LOW TAILWATER

RIPRAP SIZE - D50 (inches)

PIPE DIAMETER

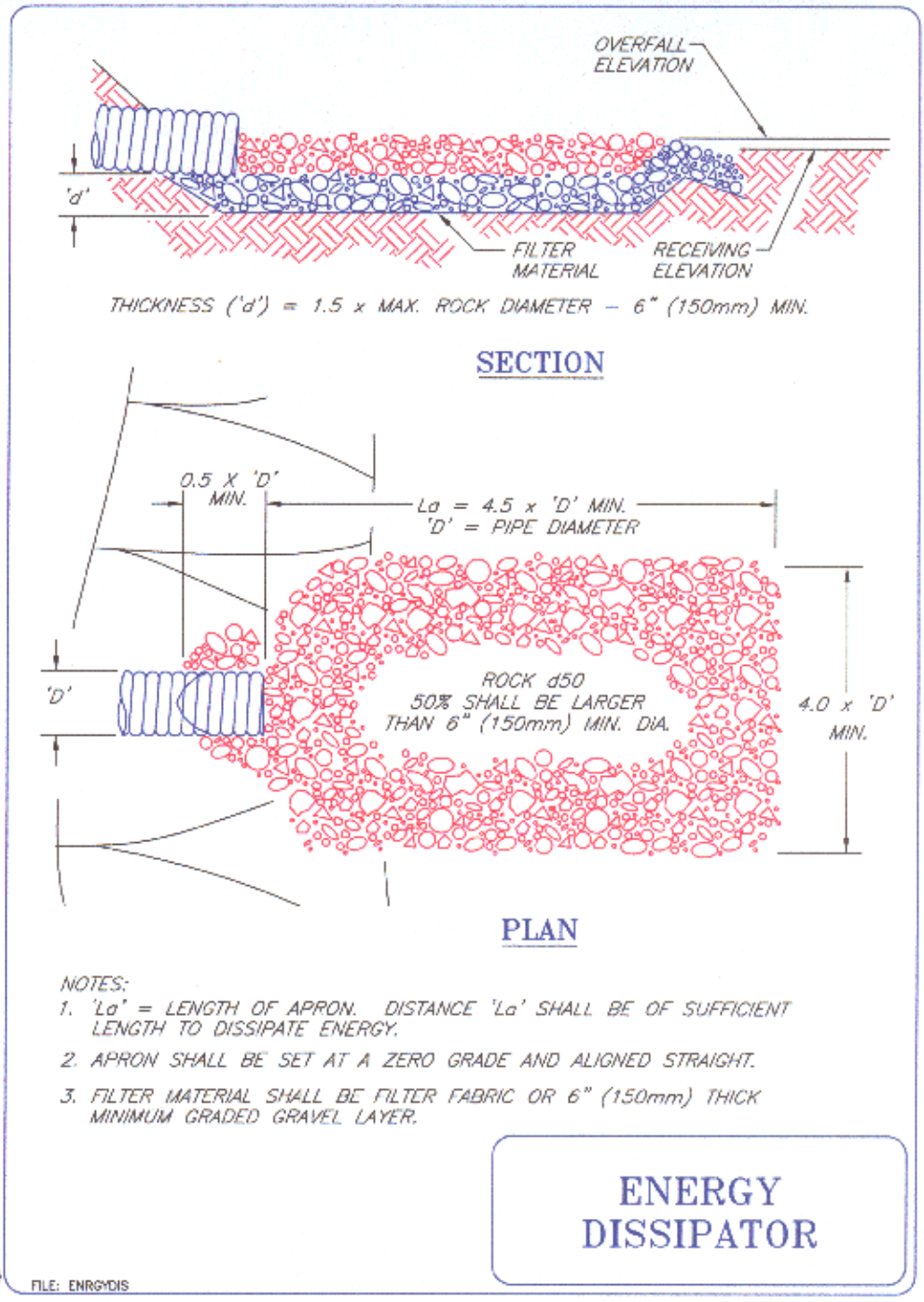
DISCHARGE	12"	15"	18"	21"	24"	27"	30"	36"	42"	48"	54"	60"
3cfs	4											
5cfs	4											
8cfs	5	4										
10cfs	6	5	4									
12cfs	8	6	6									
15cfs	8	6	8	5								
17cfs		8	8	5								
20cfs		10	10	6	5							
25cfs		12	12	6	6							
30cfs				8	8	6						
40cfs				12	10	8	6					
50cfs				16	12	10	8	6				
60cfs				18	16	12	10	8				
70cfs					18	15	12	8				
80cfs					20	16	15	10	8			
90cfs						18	16	12	10			
100cfs						20	18	12	10			
125cfs						24	20	16	12	10		
150cfs							24	20	16	12	10	
200cfs								24	20	18	15	12

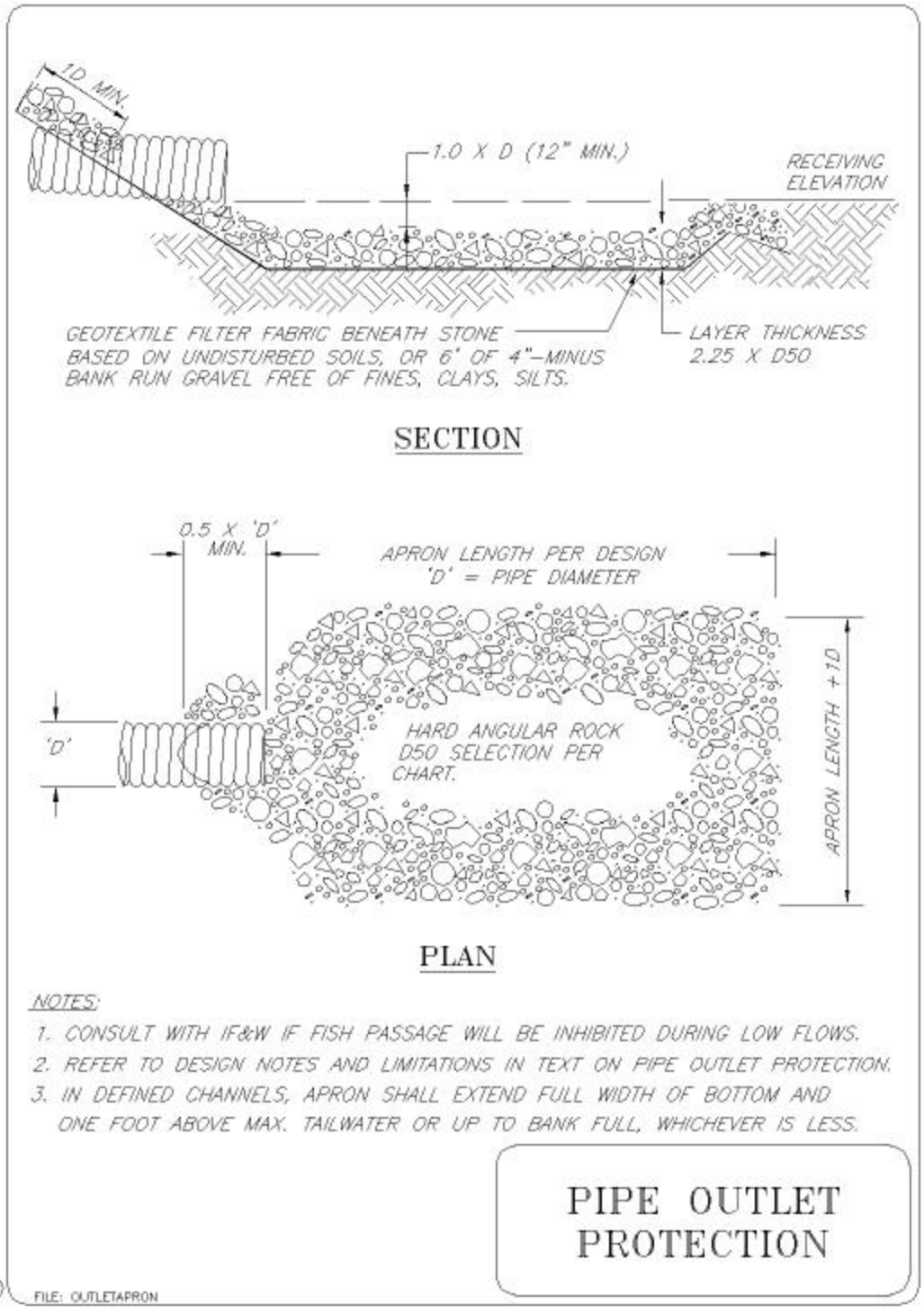
MINIMUM LENGTH OF APRON (FEET)

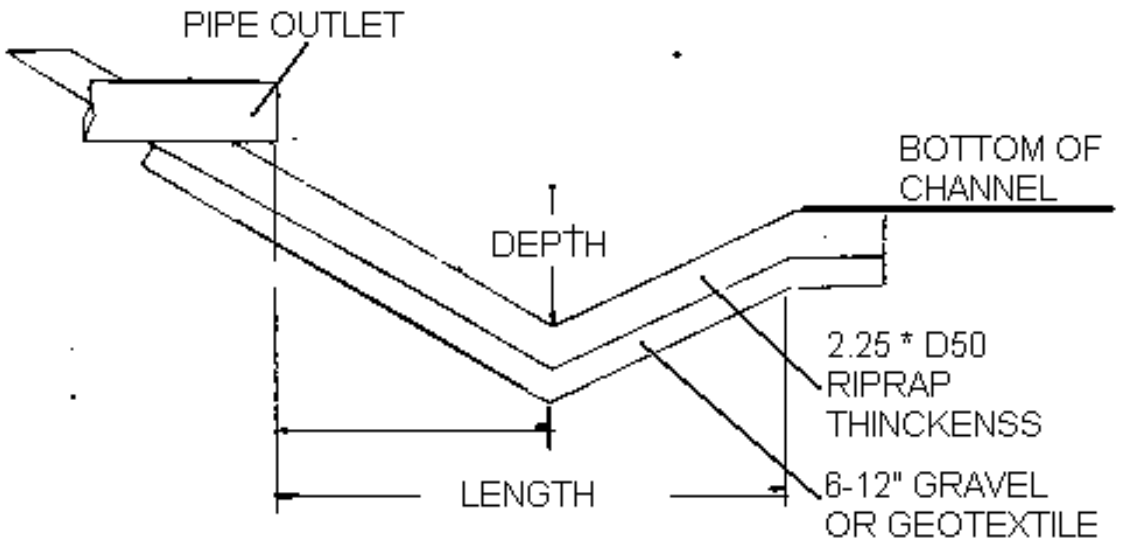
PIPE DIAMETER

DISCHARGE	12"	15"	18"	21"	24"	27"	30"	36"	42"	48"	54"	60"
3cfs	8											
5cfs	8											
8cfs	11	10										
10cfs	14	12	10									
15cfs	18	16	14	12								
20cfs		18	18	16	12							
30cfs			22	20	18	16						
40cfs			26	24	24	20	18					
50cfs				26	26	24	22	18				
70cfs					30	30	28	25				
100cfs						36	36	33	27			
150cfs						42	42	42	38	33	28	
200cfs								48	45	42	37	32

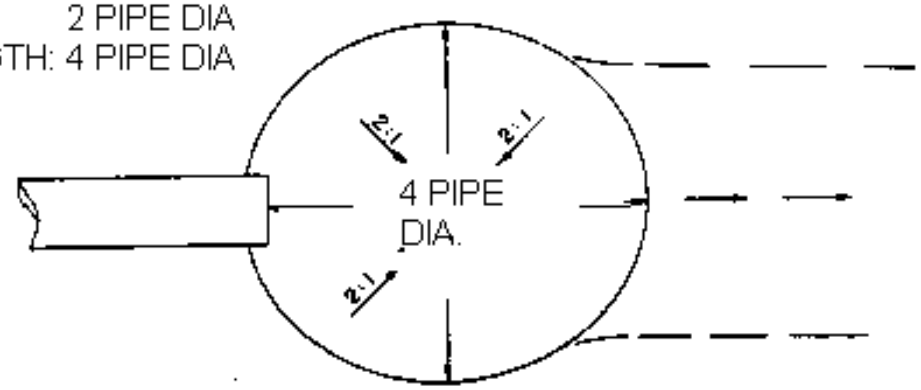
From USDA Soild Conservation Service


OVERFALL ELEVATION
'd'
FILTER MATERIAL
RECEIVING ELEVATION
THICKNESS ('d') = 1.5 x MAX. ROCK DIAMETER – 6" (150mm) MIN.
SECTION
0.5 X 'D' MIN.
La = 4.5 x 'D' MIN.
'D' = PIPE DIAMETER
'D'
ROCK d50
50% SHALL BE LARGER
THAN 6" (150mm) MIN. DIA.
4.0 x 'D' MIN.
PLAN
NOTES:
1. 'La' = LENGTH OF APRON. DISTANCE 'La' SHALL BE OF SUFFICIENT LENGTH TO DISSIPATE ENERGY.
2. APRON SHALL BE SET AT A ZERO GRADE AND ALIGNED STRAIGHT.
3. FILTER MATERIAL SHALL BE FILTER FABRIC OR 6" (150mm) THICK MINIMUM GRADED GRAVEL LAYER.
ENERGY DISSIPATOR
© 1994 JOHN McCULLAH
FILE: ENRGYDIS


1D MIN.
1.0 X D (12" MIN.)
RECEIVING ELEVATION
GEOTEXTILE FILTER FABRIC BENEATH STONE BASED ON UNDISTURBED SOILS, OR 6" OF 4"–MINUS BANK RUN GRAVEL FREE OF FINES, CLAYS, SILTS.
LAYER THICKNESS 2.25 X D50
SECTION
0.5 X 'D' MIN.
APRON LENGTH PER DESIGN 'D' = PIPE DIAMETER
'D'
HARD ANGULAR ROCK D50 SELECTION PER CHART.
APRON LENGTH = 1D
PLAN
NOTES:
1. CONSULT WITH IF&W IF FISH PASSAGE WILL BE INHIBITED DURING LOW FLOWS.
2. REFER TO DESIGN NOTES AND LIMITATIONS IN TEXT ON PIPE OUTLET PROTECTION.
3. IN DEFINED CHANNELS, APRON SHALL EXTEND FULL WIDTH OF BOTTOM AND ONE FOOT ABOVE MAX. TAILWATER OR UP TO BANK FULL, WHICHEVER IS LESS.
PIPE OUTLET PROTECTION
© 1994 JOHN McCULLAH ME DEP 2003
FILE: OUTLETAPRON



PLUNGE POOL
DEPTH: 1 PIPE DIA
SIDE: 2 PIPE DIA
LENGTH: 4 PIPE DIA



OUTLET PLUNGE POOL